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Chemical Composition of Airborne PM10 Particles from the Salton Sea Playa: Development and Severity of Asthma in Children under 14 in Imperial County

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Background

The Salton Sea, located in the Imperial and Coachella valleys, was created in 1905 by an accidental breach of Colorado river irrigation canals, leading to the flooding of the Salton desert basin (Pearce, 2003). Originally a fresh body of water, the salinity of the sea gradually increased due to evaporation and agricultural runoff, prompting mass eutrophication, fish die-off and a significant decline in bird population.

Due to the loss of popularity of the Salton Sea as a tourist destination and the importance of water as a resource in desert climates, water flow to the Salton Sea has steadily decreased, culminating in a 2018 water agreement that will reduce input to the sea by 40% (Parajuli & Zender, 2018). The area of exposed lakebed, or playa, has increased as the water recedes (*below*), leaving heavily polluted Salton Sea sediment at risk for aeolian erosion.

Figure 2. Contours of the Salton Sea at 228ft (69.5 m) below sea level represented by the light green color and at 254ft (77.4 m) below sea level represented by the light blue color (Parajuli & Zender, 2018)

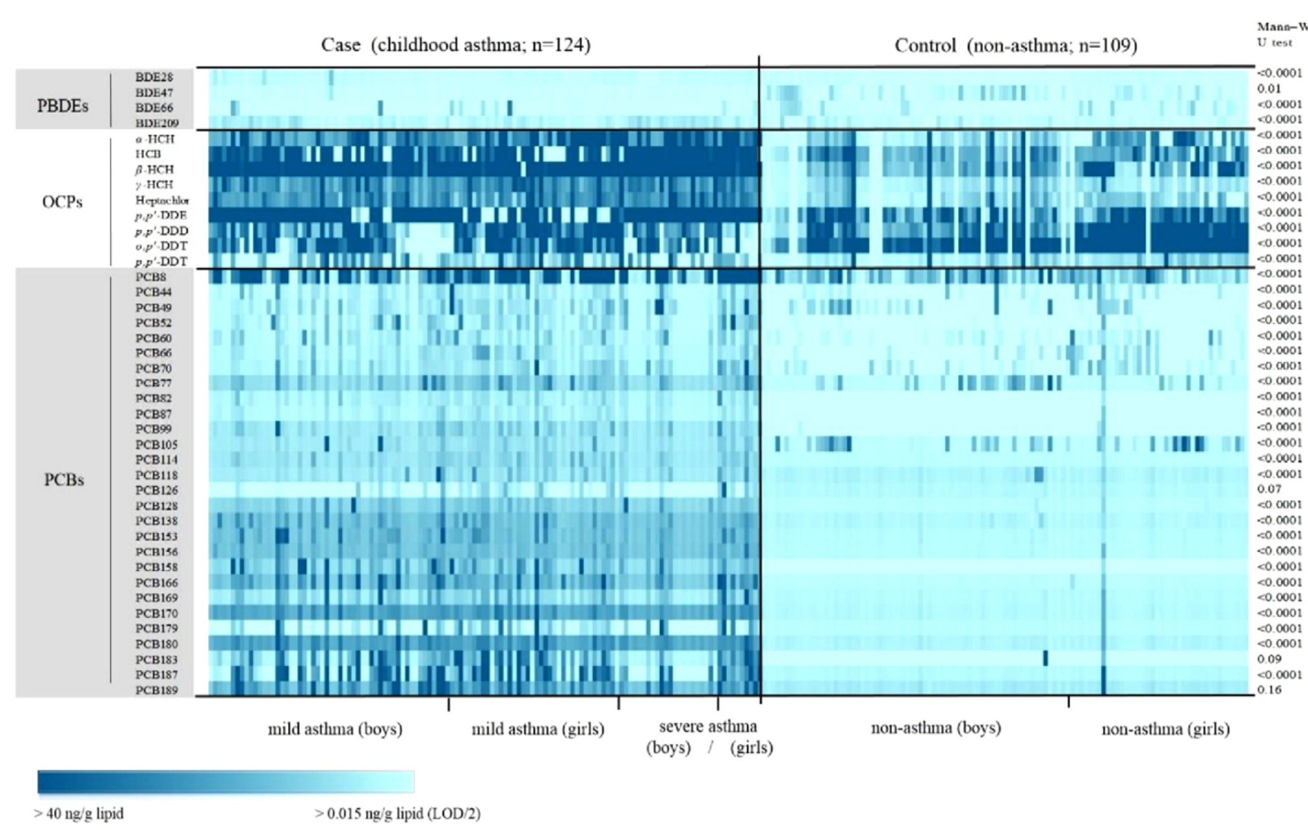
Air Pollution in the Salton Sea Area

The fine particulate matter of Salton Sea playa is a notable source of PM10, which Frie et al. predict will become an increasingly significant proportion of ambient PM10 levels as more of the sea is exposed. As early as 1998, English et al. claimed in their article, "Childhood Asthma along the United States/Mexican Border," that high levels of PM10, which is defined as particulate matter that is 10 or fewer micrometers in diameter in Imperial County may be the aggravating factor for childhood respiratory illness. Between 1983 and 1998, English et al. found that Imperial County consistently had PM10 levels that were above federal and state safety standards.

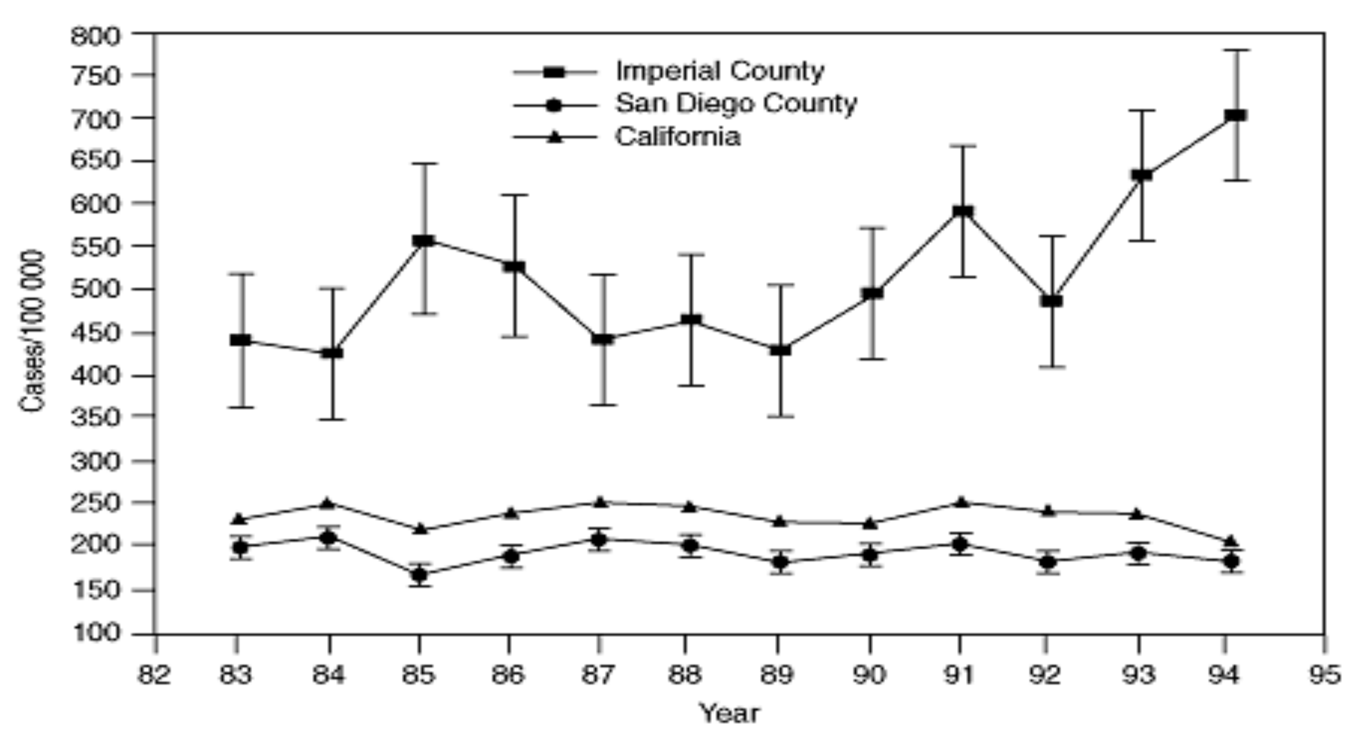
PM10 is a concern to air quality due to its invasive nature, capable of penetrating deep within the lungs and entering the bloodstream (EPA, 2018). As of 2017, a year before the current water transfer began, "playa sources contributed at an average of $8.9 \pm 5.6\%$, (2.2 ± 1.6 μg m−1) to PM10 mass over all sampling periods" (Frie et al., 8289)As the water level of the Salton Sea continues to decrease, both Parajuli and Zender and Frie et al. predict an associated increase in PM10 originating from the playa.

Impact of PM10 Composition

Airborne pesticides in PM10 form, such as DDT, PCBs, and OCPs have been associated with respiratory distress and the development of asthma. Repeated exposures to complex chemicals, particularly POPs, such as PCBs and DDT is a significant threat to human health and is particularly threatening to children due to their state of development and vulnerability (Meng et al. 2015). Gupta et al. supports this statement, adding that children are also strongly affected by air pollution due to narrower airways and a high rate of respiration. Persistent organic pollutants are particularly damaging to human health due to their high toxicity and potential for bioaccumulation, and can enter the lungs and bloodstream while in the form of airborne PM10. According to Meng et al., 25 varieties of POPs, including the PCB congeners -8, -44, -170 and -99, as well as the organochloride pesticides DDE and HCH, were positively correlated with the development of childhood asthma, demonstrating a relationship between airborne pesticides and later development of childhood asthma. When analyzing the sera of childhood asthma cases against the control group, Meng et al. found that that as the concentrations of these chemicals in sera increased, so did the levels of childhood asthma *(below, top)*



Concentrations of target compounds (left) in sera of case-control groups. Different chemical classes are grouped by horizontal lines within the figure, whereas a vertical line is applied to distinguish the case and control groups. P values (right) and characteristics of the subgroups (bottom) are also shown *(Meng et al., 2015)*



Age-adjusted childhood asthma hospitalization rates and 95% confidence intervals (95%CI), California border counties, 1983-1994. (English et al., 1998)

Ambient PM10 and Asthma

The health concern with the most potential impact and academic attention is the potential association between PM10 and the incidence of childhood asthma, due to the high mortality and rising morbidity of childhood asthma (Akinbami, 2006) and the health complications childhood asthma causes in adults (Fletcher, 2010).

These dust-borne air pollutants will have a notable effect on children due to their immaturity and high respiration rate (Gupta et al., 2016). Both the particle size of PM10 (Clark et al., 2010) and presence of dust-borne persistent organic pollutants (POPs) (Meng et al., 2015), have been linked to the development of childhood asthma, suggesting that not only will children be notably more effected by the increasing level of ambient air pollution, but will also be more likely to develop childhood asthma, which according to Fletcher et al., is a condition with long-term effects on overall health.

Conclusion

The recession of the Salton Sea and the subsequent exposure of playa will increase the rates of development of asthma in children in the Salton Sea area and Imperial County. The airborne sediment will cause a strong negative change in respiratory health due to the fine particle mass (PM10) and high levels of persistent organic pollutants sourced from agricultural runoff, such as DDT and PCBs, among other elemental components such as copper.

References

•Akinbami, LJ. (2006). The State of childhood asthma, United States, 1980–2005. Advance data from vital and health statistics. no 381, Hyattsville, MD: National Center for Health Statistics.

•Akitson, R.W., Carey, I.M., Kent, A.J., van Staa, T.P., Anderson, H.R. & Cook, D.G. (2015). Long-term exposure to outdoor air pollution and the incidence of chronic obstructive pulmonary disease in a national English cohort. *Occupational and Environmental Medicine 72*(1), 42-48. doi: 10.1136/oemed-2014-102266

•Clark, N.A., Demers, P.A., Karr, J.C., Koehoorn, M., Lencar, C., Tamburic, L., & Brauer, M. (2010). Effect of early life exposure to air pollution on development of childhood asthma. *Environmental Health Perspectives 118*(2), 284-290. doi:10.1289/ehp.0900916

•Donaldson, K., Gilmour, I.M., & MacNee, W. (2000). Asthma and PM10. *Respiratory Research 1*(1), 12-15. doi: [10.1186/rr5]

•English, P.B., Von Behren, J., Harnly, M., & Neutra, R.R. (1998). Childhood asthma along the United States/ Mexico border: hospitalizations and air quality in two California counties. *Pan Am J Public Health 3*(6), 392-399. https://doi.org/10.1590/s1020-49891998000600005

•Fletcher, J.M., Green, J.C. & Neidell, J.M. (2010). Long term effects of childhood asthma on adult health. *Journal of Health Economics 29(3),* 377-387. https://doi.org/10.1016/j.jhealeco.2010.03.007

•Frie, A.L., Dingle, J.H., Ying, S.C., & Bahrenini, R. (2017). The effect of a receding saline lake (the Salton Sea) on airborne particulate matter composition. *Environ. Sci. Technol 51* (15), 8283-8292. doi: 10.1021/acs.est.7b01773

•Gehring, U., Beelen, R., Eeftens, M., Hoek, G., de Hoogh, K., de Jongste, J. C., …Brunekreef, B. (2015). Particulate matter composition and respiratory health: The PIAMA birth cohort study. *Epidemiology 26*(3) 300-309. doi:10.1097/EDE.0000000000000264

•Gupta, S., Agarwal, R., & Mittal, K. S. (2016). Respiratory health concerns in children at some strategic locations from high PM levels during crop residue burning episodes. *Atmospheric Environment 137*(2016), 127-134. https://doi.org/10.1016/j.atmosenv.2016.04.030

•Guy, A. B. (2018). Pollution Solution for Salton Sea. Retrieved December 8, 2018, from http://plantandmicrobiology.berkeley.edu/news/pollution-solution-salton-sea

•Katsoyiannis, A. & Bogdal, C. (2012). Interactions between indoor and outdoor air pollution-Trends and scientific challenges. *Environmental Pollution 169*(2012), 150-151.

•Liu, D. &Abuduwaili, J. (2013) Wind erosion at a saline playa environment, Ebinur lake, Xinjiang, China – A case study on the source of saline dust storm. *Applied Mechanics and Materials 201* (260-261), 1003-1008

•Miller, M.D., & Marty, M.A. (2010). Impact of environmental chemicals on lung development. *Environmental Health Perspectives 118*(8). 1155-1164. https://doi.org/10.1289/ehp.0901856

•Morman, S.A. & Plumlee, G.S. (2013) The role of airborne mineral dusts in human disease. *Aeolian Research 9* (2013), 203-212. https://doi.org/10.1016/j.aeolia.2012.12.001

•O'byrne, P.M., & Postma, D.S. (1999). The many faces of airway inflammation. Asthma and chronic obstructive pulmonary disease. Asthma Research Group. *American Journal of Respiratory and Critical Care Medicine 159*(5), 41-63. Doi: https://doi.org/10.1164/ajrccm.159.supplement_2.mfa-1

•Particulate Matter (PM) Basics. (2018). *United States Environmental Protection Agency* https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

•Parajuli, S.P., & Zender, C.S. (2018). Projected changes in dust emissions and regional air quality due to the shrinking Salton Sea. *Aeolian Research, 33*(2018), 82-92.https://doi.org/10.1016/j.aeolia.2018.05.004

•Pearce, F. (2003). Sun, sea and Sinatra. *New Scientist 2402*(179), 48.

•Roth, S., & James, I. (2017, June 10). Salton Sea: California far from solutions as Salton Sea crisis looms. Retrieved December 8, 2018, from https://www.usatoday.com/pages/interactives/salton-sea/california-far-from-solutions-as-salton-sea-crisis-looms/

•Sapozhnikova, Y., Bawardi, O., & Schlenk, D. (2003). Pesticides and PCBs in sediments and fish from the Salton Sea, California, USA. *Chemosphere 55*(2003), 797-809. doi: 10.1016/j.chemosphere.2003.12.009

•Schroeder, R.A., Orem, W.H., & Kharaka, Y.K. (2002). Chemical evolution of the Salton Sea, California: nutrient and selenium dynamics. *Hydrobiologia 473*(2002), 23-45. doi:10.1023/A:1016557012305

•Webb, H. (2018). Things you should know about PM10 and how to protect yourself. [Graphic]. Retrieved December 9, 2018, from https://cambridgemask.com/wp-content/uploads/2018/04/PM10-01.png

•Weinmayr, G., Romeo, E., De Sario, M., Weiland, S.K., & Forastiere, F. (2010). Short-term effects of PM10 and NO2 on respiratory health among young children with asthma or asthma-like symptoms: A systematic review and meta-analysis. *Environmental Health Perspectives 118* (4), 449-457. doi:10.1289/ehp.0900844

•Xu, E.G., Bui, C., Lamerdin, C., & Schlenk, D. (2016). Spatial and temporal assessment of environmental contaminants in water, sediments and fish of the Salton Sea and its two primary tributaries, California, USA, from 2002 to 2012. *Science of the Total Environment*